Strategic goal: Eliminate ground failure fatalities and injuries in the mining industry.
Ground Fall Injuries
Historical perspective

- Most likely cause of fatalities (43% since 1995).
- Over 50,000 miners have been killed in past 100 years by falls of ground.
- Mostly small accidents claiming one or two lives at a time.

Why do they happen?
Falls-of-ground fatalities (UG coal)

Why do they happen?

(Excludes contractors, BOM, MSHA 1910-2009)
Causes of ground fall fatalities


- Pillaring: 21%
- Inby: 20%
- Rib Falls: 17%
- Skin Falls: 13%
- Burst/Bump: 11%
- Misc.: 9%
- Roof Falls (above bolts): 10%
Assessing ground control problems ...

- **Global stability**
  - Massive pillar collapse
  - Bumps
  - Squeezes

- **Local stability**
  - Roof falls
  - Rib rolls

- **Surface control**
  - Failure between supports
Break down of ground control fatalities

- Surface instability: 42%
- Local instability: 47%
- Global instability: 11%
Preventing ground failures . . .

- Global stability
- Local stability
- Surface control
- Engineering design
- Cultural changes
Ground Control Project Portfolio

7 projects coal sector
4 projects metal/non-metal sector
The coal sector

1. Calibration and Verification of Longwall Stress Models
2. Empirical Guidelines for Longwall Ground Control Design
3. Identification of Areas at Risk for Coal Bursts in Deep Cover Room and Pillar
4. Coal Mine Safety Applications of Seismic Monitoring
5. Optimizing the Design and Application of Roof Support
7. Mine Roof Simulator (MRS)
8. Reducing Ground Fall Hazards In Coal Mines With Low Strength Roof
Program focus in the coal sector

- Deep cover issues (longwall and retreat mining)
- Fundamental design issues for roof bolting
- Design criteria for longwall tailgate support
- Evaluation of design and analysis tools for roof control approval
- Assessing the utility of seismic monitoring
- Evaluation of new roof support products
- Support of weak roof conditions
- Updating empirical design programs
Deep cover retreat mining

- Examined deep cover cases.
- Updated (ARMPS).

More accurately simulates overburden behavior in competent, stiff, strata.
Identification of Areas at Risk for Coal Bursts in Deep Cover Room and Pillar Mines

- Exercise caution when mining beyond 1,000 ft.
- Identify areas of increased risk (particularly bursts) due to geological factors, multiple seam interactions, past experience.
- Seek to avoid them.

Deep cover retreat mining.
Calibration and Verification of Longwall Stress Models

Crandall Canyon Mine Disaster

MSHA PIB P09-03 (Using Numerical Modeling)

Detailed instrumentation study at Elk Creek Mine

Monitor ground behavior and evaluate pillar performance under deep cover (>2,000 ft).
Coal Mine Safety Applications of Seismic Monitoring

- Adapt seismic systems to the coal environment.
- Can we take it to the next level?
  - Move beyond major hazard risk awareness ....
  - ...into the cause (source of event) and solution (mine design) phase.
Application of the ground reaction concept to roof support design

How do you decide what support is best to use?

Match the support design to the ground response.
Support Design Procedures for Difficult Ground Conditions

Roof bolting universal primary support practice for rock reinforcement

Massive Bedded

No universal roof support design methodology

UDEC model results

OFFICE OF MINE SAFETY AND HEALTH RESEARCH
Empirical Guidelines for Longwall Ground Control Design

Update the case history data base.

Modify design guidelines as needed.
The Mine Roof Simulator

- Longstanding program to assist support mfgs to develop new support products.
- Ensure safety by defining their performance characteristics and limitations.
Opportunities for partnerships

Worked with 10 different support mfgs in 2010.
Other opportunities for partnerships

• Roof bolt behavior.
• Red zone assessment.
• Ground response instrumentation studies.
• Seismic evaluations.